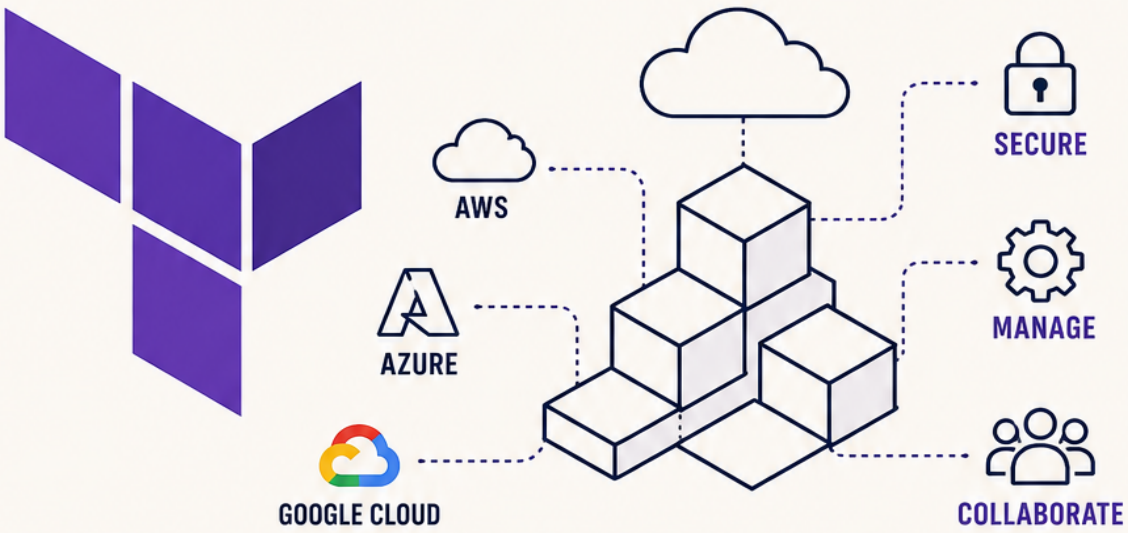
ZERO TO PRODUCTION MASTERY

TERRAFORM

A COMPREHENSIVE GUIDE

FROM FIRST CONFIGURATION TO PRODUCTION INFRASTRUCTURE AT SCALE



LEARN
Terraform language, core concepts, and best practices

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Real infrastructure with complete, working examples

OPERATE
Apply proven patterns for reliable and scalable infrastructure

SCALE
Organize and manage infrastructure across environments and teams

JOHN FLETCHER

Terraform: A Comprehensive Guide

From First Configuration to Production Infrastructure at Scale

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From First Configuration to Production Infrastructure at Scale

This book takes you from zero Terraform experience to production-level mastery. You will learn the language, architecture, and operational patterns needed to manage real infrastructure safely at scale. Every concept is explained with complete working examples, realistic cloud provider scenarios, and guidance on when each feature should be used, or avoided. The focus is on practical understanding: not just how Terraform works, but why it works that way, what trade-offs are involved, and how experienced teams organize their configurations for reliability, security, and collaboration.

Chapter 1: The Infrastructure Problem and the Code Solution

The Chaos of Manual Infrastructure

Imagine a small startup in 2015. Three engineers share responsibilities across product development, server management, and deployments. When they need a new web server, one engineer logs into the cloud provider dashboard, clicks through menus to create an EC2 instance, configures security groups through another set of screens, sets up DNS records, and installs software by SSHing in and running commands copied from a wiki page. This works fine for the first handful of servers.

Six months later, the startup has grown. There are now twenty-five instances spread across three regions, managed by five people with different levels of experience. One engineer remembers how to configure the load balancer correctly. Another has a slightly different process for setting up databases. A critical production server was rebuilt after a failure using an outdated procedure, and now it is missing a security patch that other servers have. Nobody knows exactly what configuration any given server actually runs, because those details live in people's heads, scattered wiki pages, and the cloud provider's web console history.

This scenario describes infrastructure managed through manual processes and point-and-click interfaces, what engineers call "click-ops." The problems are not unique to startups. Large enterprises face even worse versions of this chaos: hundreds of servers, dozens of teams making independent changes, compliance requirements demanding documentation of every configuration decision, and an inability to answer simple questions like "what changed in production last week" or "how do we recreate this environment from scratch?"

The core issues with manual infrastructure management fall into several categories. First is reproducibility: when you build something through a graphical interface or ad-hoc scripts, recreating it exactly is difficult even for the person who built it originally. Second is documentation decay: any

written procedures drift out of sync with reality as soon as someone makes an undocumented change. Third is inconsistency: different people interpret requirements differently, leading to subtle configuration differences between environments that cause bugs appearing only in production. Fourth is risk: manual changes bypass review processes, making it easy to introduce errors or security misconfigurations without anyone noticing until something breaks. Fifth is speed: manually provisioning infrastructure takes time proportional to the number of resources, and this becomes a bottleneck as organizations grow.

These are not theoretical problems. They are the daily reality for teams that have not adopted systematic approaches to infrastructure management. The industry response has been Infrastructure as Code.

What Infrastructure as Code Means

Infrastructure as Code is the practice of managing and provisioning computing infrastructure through machine-readable definition files rather than physical hardware configuration or interactive configuration tools. Instead of clicking through a web console to create a server, you write a file describing what that server should look like, its size, operating system, network configuration, security settings, and use software to create it from that description.

The word "code" here is intentional. Infrastructure as Code means treating your infrastructure definitions with the same rigor you apply to application code: version control, code review, automated testing, continuous integration, and systematic change management. When you make a change to your infrastructure, you modify a file in a repository, submit it for review, discuss the changes with your team, and merge it through the same process you use for application changes. This creates an auditable history of every infrastructure modification: who made it, when, why, and what exactly changed.

Infrastructure as Code provides several concrete benefits over manual management. Reproducibility becomes automatic: running the same code against a fresh environment produces identical results every time. Documentation is inherent in the code itself, always synchronized with reality because the code is what actually creates the infrastructure. Consistency emerges naturally because all environments are built from the same definitions, parameterized only by intentional differences like instance sizes or region selections. Risk decreases because changes go through review before taking

effect, and you can see exactly what will change before applying it. Speed increases dramatically because provisioning is automated and can create dozens of resources in parallel rather than one at a time through a web interface.

Beyond these operational benefits, Infrastructure as Code enables practices that would be impractical with manual infrastructure. You can spin up temporary environments for testing new features and tear them down when done. You can recreate an entire production environment from scratch if disaster strikes. You can maintain parity between development, staging, and production by using the same code with different parameters. You can track infrastructure costs over time by correlating changes in your code with changes in your bills.

Infrastructure as Code is not a single tool or technology. It is a philosophy of how to approach infrastructure management, implemented through various tools that share common principles. Terraform is one of the most widely adopted implementations of this philosophy, and understanding why it has gained such traction requires examining how it differs from alternatives, both manual approaches and other automated tools.

Declarative Versus Imperative Approaches

Infrastructure automation tools can be broadly classified into two categories based on how they describe desired infrastructure: declarative and imperative. Understanding the difference between these approaches is fundamental to understanding Terraform's design and why it behaves the way it does.

Imperative infrastructure tools tell the system exactly how to build something, step by step, in a specific order. You write instructions like "create this server," then "install this software on it," then "configure this service," then "start that process." Each command performs an action, and the final state of your infrastructure depends on executing all commands correctly in the right sequence. Traditional shell scripts, Ansible playbooks (to a significant degree), and cloud provider SDKs used programmatically are examples of imperative approaches.

Declarative tools like Terraform take a different approach. Instead of specifying how to build infrastructure, you specify what the final result should look like. You describe your desired state: "I need three web servers in an auto-scaling group behind a load balancer, with this security group and these

tags." The tool then figures out what actions are necessary to reach that state from whatever currently exists. If nothing exists, it creates everything. If some resources already exist but do not match your description, it modifies them. If extra resources exist that you no longer described, it removes them (or warns you about them).

This difference has profound practical implications. With imperative tools, you must carefully manage state and idempotency yourself. A script that installs software must check whether the software is already installed and skip installation if it is, otherwise running the script twice causes problems. You must also handle ordering: if step three depends on step two completing successfully, your script must ensure that dependency is respected. As infrastructure grows more complex, these concerns become increasingly difficult to manage correctly.

Declarative tools handle idempotency and ordering automatically. Running Terraform against the same configuration multiple times produces the same result without side effects, because each run compares the desired state against the current state and only makes changes necessary to bring them into alignment. Dependencies between resources are inferred from your configuration: if resource B references an attribute of resource A, Terraform knows it must create or update A before B. This means you can describe complex infrastructure with many interdependent components without worrying about the order in which they are created.

The declarative approach also makes change management more intuitive. When you want to modify your infrastructure, you edit the description of what you want and let the tool figure out how to get there. With imperative tools, adding a new step or changing an existing one requires understanding the entire sequence and ensuring your changes do not break the flow.

However, declarative is not universally superior. Imperative approaches can be more appropriate for certain tasks: complex procedural logic that does not fit neatly into resource definitions, configuration management on individual machines where you need fine-grained control over package installation order, or scenarios where you need to interact with systems in ways that do not map cleanly to infrastructure resources. Many production environments use both declarative and imperative tools together: Terraform for provisioning cloud resources, Ansible or similar tools for configuring software on those resources.

Terraform is fundamentally declarative, and this shapes everything about

how it works. You describe what you want, and Terraform manages the process of getting there. This design choice enables many of Terraform's strengths, predictable behavior, automatic dependency management, safe concurrent operations, while also creating some limitations that experienced users must work around.

How Terraform Fits Into the IaC Landscape

Terraform is not the only Infrastructure as Code tool available, and understanding its position relative to alternatives helps clarify when it is the right choice and when other tools might be more appropriate. The IaC ecosystem can be roughly divided into several categories.

Cloud-native tools are provided by individual cloud providers and manage resources specific to that provider. AWS CloudFormation, Azure Resource Manager templates, and Google Cloud Deployment Manager fall into this category. These tools have deep integration with their respective platforms, often supporting the latest features before third-party tools do. However, they lock you into a single cloud: deploying identical infrastructure across AWS and Azure requires writing configurations in two different languages with different paradigms. Terraform was designed from the beginning to be multi-cloud, using the same language and workflow regardless of which providers you target.

Configuration management tools focus on ensuring individual machines have the correct software installed and configured correctly. Ansible, Chef, Puppet, and SaltStack are prominent examples. These tools excel at managing application configuration, installing packages, editing configuration files, starting services, but are less suited for provisioning cloud resources like virtual networks, load balancers, and databases. Many teams use Terraform and a configuration management tool together: Terraform provisions the infrastructure, then Ansible or Chef configures the software running on it. Modern practices increasingly favor immutable infrastructure where servers are replaced rather than modified in place, reducing the need for separate configuration management tools.

Higher-level orchestration tools abstract away much of the underlying infrastructure complexity. Kubernetes manifests, Pulumi (which uses general-purpose programming languages instead of a domain-specific language), and

CDK frameworks allow you to describe application architectures at a higher level of abstraction. These tools can be excellent choices for specific use cases but often hide details that experienced engineers need access to. Terraform sits at an intermediate level: it exposes the underlying cloud resources directly while providing structure and automation around managing them.

Open-source versus proprietary considerations have also shaped the landscape. Terraform was originally released under an open-source license (MPL 2.0) by HashiCorp in 2014. In August 2023, HashiCorp changed Terraform's license to the Business Source License (BUSL), a source-available but not open-source license that restricts how the software can be used commercially. This change prompted the creation of OpenTofu, a community fork maintained under Linux Foundation governance with an MPL 2.0 license. As of 2026, both Terraform and OpenTofu remain widely used, sharing most core functionality while diverging on licensing, governance, and some features. The technical concepts covered in this book apply to both tools, though specific commands and some advanced features differ.

Terraform's primary strengths that distinguish it from alternatives include: multi-cloud support through a single language and workflow; a mature ecosystem of providers covering thousands of services across cloud platforms, on-premises systems, and SaaS products; explicit state management that tracks exactly what infrastructure exists and how it relates to your configuration; modularity for packaging reusable infrastructure patterns; strong community adoption resulting in extensive documentation, third-party tools, and shared knowledge; and a clear separation between provisioning (creating resources) and configuration management (setting up software on those resources).

Its limitations include: the state file being a single point of failure that must be protected carefully; slower execution compared to imperative tools for some operations because it must refresh and compare state before making changes; limited built-in support for complex procedural logic; and a learning curve for teams accustomed to imperative scripting or cloud-native tools.

For most organizations managing infrastructure across one or more cloud providers, Terraform provides an excellent balance of power, flexibility, and ecosystem maturity. The rest of this book focuses on using Terraform effectively within that context.

Core Principles That Guide Terraform Design

Understanding Terraform's underlying design principles helps you use it more effectively and anticipate how it will behave in unfamiliar situations. Several key principles shape the tool's architecture and workflow.

The first principle is immutability. Terraform treats infrastructure as something to be replaced rather than modified in place whenever possible. When a resource cannot be updated with new configuration, Terraform destroys the old version and creates a new one rather than attempting complex in-place modifications. This approach simplifies reasoning about infrastructure changes: you know that applying your configuration produces a predictable result without hidden side effects from partial updates or stateful mutations. Immutability also enables safe rollbacks, reverting to a previous configuration recreates the previous infrastructure exactly.

The second principle is explicit state. Terraform maintains a detailed record of every resource it manages, including unique identifiers, current attribute values, and dependencies between resources. This state file is central to how Terraform operates: it uses state to determine what changes are needed, to track which real-world resources correspond to which configuration elements, and to optimize performance by avoiding unnecessary API calls. The explicit nature of this state means you can inspect exactly what Terraform believes your infrastructure looks like, which is invaluable for debugging and auditing. It also means state must be treated as a critical asset: losing or corrupting it can make managed infrastructure difficult or impossible to manage through Terraform.

The third principle is declarative configuration. As discussed earlier, Terraform configurations describe desired outcomes rather than procedural steps. This means you focus on what your infrastructure should look like, and Terraform handles the mechanics of getting there. The declarative model enables powerful features like drift detection, comparing actual infrastructure against desired state to detect changes made outside Terraform, and safe concurrent operations, since multiple engineers can work on different parts of a configuration without worrying about execution order.

The fourth principle is modularity. Terraform encourages breaking infrastructure into reusable components called modules. A module packages related resources together with defined inputs and outputs, allowing you to use the same infrastructure pattern in multiple places with different parameters. This

supports consistency across environments, reduces duplication, and enables teams to build shared libraries of proven infrastructure patterns.

The fifth principle is versioned change management. Terraform integrates naturally with version control systems because configurations are plain text files. Every change to infrastructure goes through the same review and approval process as application code changes. Combined with the plan-then-apply workflow, where you can see exactly what changes will be made before committing to them, this creates a robust change management process that reduces risk and improves team collaboration.

These principles are not just abstract ideals; they directly influence how you should structure your Terraform configurations, organize your projects, and operate in production environments. As you progress through this book, you will see these principles reflected in the patterns and practices recommended for real-world use. The goal is not merely to learn Terraform syntax but to internalize the mindset that makes Terraform effective: treating infrastructure as versioned, testable, composable code rather than ephemeral configurations managed through interactive tools.

Chapter 2: Getting Started with Terraform

Installing Terraform and Verifying Your Setup

Terraform is distributed as a single binary with no external dependencies, making installation straightforward on all major operating systems. The current stable version series is 1.15.x as of mid-2026, with regular patch releases addressing bugs and security issues. You can find the latest release at https://releases.hashicorp.com/terraform/ or through package managers depending on your platform.

On macOS with Homebrew installed, run:

```
brew tap hashicorp/tap
brew install hashicorp/tap/terraform
terraform -version
```

On Linux, you can download the binary directly from HashiCorp's releases page, extract it, and place it in your PATH. For Ubuntu or Debian-based systems using the official repository:

```
curl -fsSL https://apt.releases.hashicorp.com/gpg | sudo gpg --dearmor -o
  ↪  /usr/share/keyrings/hashicorp-archive-keyring.gpg
echo "deb [signed-by=/usr/share/keyrings/hashicorp-archive-keyring.gpg]
  ↪  https://apt.releases.hashicorp.com $(lsb_release -cs) main" | sudo tee
  ↪  /etc/apt/sources.list.d/hashicorp.list
sudo apt update
sudo apt install terraform
terraform -version
```

On Windows with Chocolatey:

```
choco install terraform
terraform -version
```

The `terraform -version` command confirms your installation and reports the version number. Output looks like:

```
Terraform v1.15.8
on linux_amd64
```

For development work, you may need to switch between Terraform versions, testing configurations against older versions for compatibility or trying new features in beta releases. Tools like `tfenv` (https://github.com/tfutils/tfenv) manage multiple Terraform versions on a single machine, allowing you to select which version is active per project through a `.terraform-version` file.

A note on licensing: starting with version 1.6.0, Terraform uses the Business Source License (BUSL) rather than an open-source license. The BUSL allows free use for most purposes but restricts certain commercial uses, notably offering Terraform as a managed service competing with HashiCorp's own offerings. If your organization requires strict open-source licensing, OpenTofu provides a compatible alternative under MPL 2.0. For the purposes of this book, all technical concepts apply equally to both tools; command names and some advanced features differ slightly.

Understanding the Terraform Project Layout

Every Terraform project lives in a directory containing configuration files with `.tf` or `.tf.json` extensions. Terraform reads all such files in the current directory and treats them as a single logical configuration, regardless of how you split content across multiple files. This design encourages organizing configurations into focused files rather than one monolithic file.

A minimal project contains at least one configuration file. A well-organized production project typically includes several:

```
my-project/
├── main.tf              # Resource definitions
├── variables.tf         # Input variable declarations
├── outputs.tf           # Output value definitions
├── providers.tf         # Provider and Terraform version configuration
├── terraform.tfvars     # Variable values (often excluded from version control)
└── .terraform/          # Created by terraform init; exclude from version
    ↪ control
```

This separation of concerns is a convention, not a requirement. Terraform does not care about filenames beyond the extension. However, following consistent naming conventions makes configurations easier to navigate, especially as projects grow. Many teams adopt slightly different conventions: some combine providers and version requirements into `main.tf`, others split resources by type or logical grouping into separate files like `networking.tf`, `compute.tf`, and `storage.tf`.

The `.terraform` directory is created automatically when you run `terraform init`. It contains downloaded provider plugins and, for local backend configurations, cached state information. This directory should never be committed to version control, it is generated from your configuration and can be recreated on any machine by running `terraform init`. Add it to your `.gitignore`:

```
# .gitignore
.terraform/
*.tfstate
*.tfstate.backup
*.tfplan
override.tf
*.auto.tfvars
crash.log
```

Note that the dependency lock file, `.terraform.lock.hcl`, should be committed to version control despite its name suggesting otherwise. This file records exact provider versions and checksums, ensuring all team members and CI pipelines use identical versions. We will discuss this file in more detail later.

Writing Your First Configuration File

Let us create a simple but complete configuration that provisions real infrastructure. The example uses AWS because it is the most widely used cloud

provider with Terraform, but the concepts apply regardless of which provider you target. To follow along with live examples, you will need an AWS account with appropriate permissions configured. For learning purposes without cloud credentials, HashiCorp provides a Docker-based getting-started tutorial that creates resources locally.

Create a new directory for your project and add a file named `main.tf`:

```
# main.tf

terraform {
  required_version = ">= 1.5.0"

  required_providers {
    aws = {
      source  = "hashicorp/aws"
      version = "~> 6.0"
    }
  }
}

provider "aws" {
  region = "us-east-1"
}

resource "aws_s3_bucket" "example" {
  bucket = "my-unique-bucket-name-${random_id.suffix.hex}"

  tags = {
    Name        = "example-bucket"
    Environment = "development"
  }
}

resource "random_id" "suffix" {
  byte_length = 4
}
```

Let us examine each section carefully. The `terraform` block configures Terraform itself rather than infrastructure. It specifies two things: the minimum Terraform version required to run this configuration, and which provider plugins are needed. The `required_version` constraint prevents accidental use of an older Terraform that might lack features your configuration depends on. The `required_providers` block declares that we need the AWS provider from HashiCorp's registry, version 6.x or later (the `~> 6.0` syntax means "approximately greater than 6.0", specifically, any version >= 6.0.0 and < 7.0.0).

The `provider` block configures how Terraform connects to AWS. Here we specify the region where resources will be created by default. Authentication credentials are not specified in the configuration file, they should come from environment variables, a shared credentials file (`~/.aws/credentials`), or instance profiles when running on EC2. Hardcoding credentials in configuration files is a security anti-pattern that we will address later.

The `resource` blocks define actual infrastructure. We create an S3 bucket with a unique name generated by combining a prefix with a random suffix, ensuring the bucket name does not conflict with existing buckets (S3 bucket names must be globally unique). The `tags` argument attaches metadata to the resource for organization and cost tracking. We also create a `random_id` resource from HashiCorp's random provider (which Terraform downloads automatically when referenced) to generate that unique suffix.

At this point we have described what infrastructure we want but have not created anything yet. Terraform operates in two distinct phases: planning, where it determines what changes are needed, and applying, where it executes those changes. This separation is a deliberate safety feature that lets you review planned changes before committing to them.

The Initialization Step and Provider Plugins

Before Terraform can plan or apply any configuration, it must be initialized. Run `terraform init` in your project directory:

```
$ terraform init

Initializing the backend...

Initializing provider plugins...
- Finding hashicorp/aws versions matching "~> 6.0"...
- Finding latest version of hashicorp/random...
- Installing hashicorp/aws v6.61.0...
- Installed hashicorp/aws v6.61.0 (signed by HashiCorp)
- Installing hashicorp/random v3.7.2...
- Installed hashicorp/random v3.7.2 (signed by HashiCorp)

Terraform has created a lock file .terraform.lock.hcl. This file should be
committed to version control along with your Terraform configuration files.

Terraform has been successfully initialized!
```

The `terraform init` command performs several essential tasks. First, it configures the backend, the storage location for Terraform state. By default, this is local storage in the current directory, but we will cover remote backends later. Second, it downloads and installs provider plugins specified in your configuration. Provider plugins are separate binaries that implement the interface between Terraform core and specific infrastructure platforms. When you write `resource "aws_s3_bucket"`, Terraform core delegates to the AWS provider plugin to translate that declaration into API calls against AWS.

Third, `terraform init` creates or updates the dependency lock file `.terraform.lock.hcl`. This file records the exact versions of providers selected and cryptographic checksums for each platform your team might use. Committing this file ensures reproducibility: anyone cloning your repository will get identical provider versions when they run `terraform init`, preventing subtle differences caused by automatic selection of newer patch versions.

The `.terraform` directory created during initialization contains the downloaded provider plugins. Its structure looks like:

```
.terraform/
└── providers/
    ├── registry.terraform.io/
    │   └── hashicorp/
    │       ├── aws/6.61.0/linux_amd64/
    │       │   └── terraform-provider-aws_v6.61.0
    │       └── random/3.7.2/linux_amd64/
    │           └── terraform-provider-random_v3.7.2
```

You should never manually edit files in this directory. If something goes wrong, delete the entire `.terraform` directory and run `terraform init` again to regenerate it cleanly.

Planning Changes Before Applying Them

With initialization complete, Terraform can now analyze your configuration and determine what changes are needed. Run `terraform plan`:

```
$ terraform plan

Terraform used the selected providers to generate the following execution plan.
Resource actions are indicated with the following symbols:
  + create

Terraform will perform the following actions:

  # random_id.suffix will be created
  + resource "random_id" "suffix" {
      + b64         = (known after apply)
      + b64url      = (known after apply)
      + decimal     = (known after apply)
      + hex         = (known after apply)
      + id          = (known after apply)
      + byte_length = 4
    }

  # aws_s3_bucket.example will be created
  + resource "aws_s3_bucket" "example" {
      + bucket         = (known after apply)
      + bucket_domain_name = (known after apply)
      + id             = (known after apply)
      + region         = "us-east-1"
      + tags           = {
          + "Environment" = "development"
          + "Name"        = "example-bucket"
        }
      + tags_all       = {
          + "Environment" = "development"
          + "Name"        = "example-bucket"
        }
    }

Plan: 2 to add, 0 to change, 0 to destroy.
```

The plan output is one of Terraform's most valuable features. It shows exactly what changes Terraform intends to make before any resources are created or modified. The symbols have specific meanings: `+` means create, `-` means destroy, and `~` means update in place. You can see that Terraform plans to create two resources: the random ID generator and the S3 bucket.

Some attribute values show "(known after apply)" because they are determined by the provider during resource creation, for example, the actual hex value generated by `random_id`, or the full bucket name including the random suffix. These values become known only after AWS creates the resource and returns its attributes.

If you run `terraform plan` again without changing your configuration, it reports no changes:

```
Plan: 0 to add, 0 to change, 0 to destroy.
```

This is idempotency in action: Terraform compares your desired state (the configuration) against the current state (what exists in AWS, recorded in the state file) and determines that they already match. Running plan multiple times never causes side effects because it only reads and compares; it never modifies infrastructure.

For CI/CD pipelines and automation, you can save a plan to a file with `terraform plan -out=tfplan`. This binary plan file captures the exact changes Terraform computed, so a subsequent `terraform apply tfplan` applies precisely those changes without recomputing the plan. This ensures that what was reviewed in the plan output is exactly what gets applied, even if the configuration or external state has changed in the meantime.

Creating, Updating, and Destroying Resources

To actually create the resources shown in the plan, run `terraform apply`:

```
$ terraform apply

Terraform used the selected providers to generate the following execution plan.
Resource actions are indicated with the following symbols:
  + create

Terraform will perform the following actions:

  # random_id.suffix will be created
  + resource "random_id" "suffix" { ... }

  # aws_s3_bucket.example will be created
  + resource "aws_s3_bucket" "example" { ... }

Plan: 2 to add, 0 to change, 0 to destroy.

Do you want to perform these actions?
  Terraform will perform the actions described above.
  Only 'yes' will be accepted to approve.

```

```
  Enter a value: yes

random_id.suffix: Creating...
random_id.suffix: Creation complete after 0s [id=a3f7b2c1]
aws_s3_bucket.example: Creating...
aws_s3_bucket.example: Creation complete after 2s
↪  [id=my-unique-bucket-name-a3f7b2c1]

Apply complete! Resources: 2 added, 0 changed, 0 destroyed.
```

Terraform prompts for confirmation before making changes. In interactive use, you type "yes" to proceed. For automation where interactive confirmation is not possible, use `terraform apply -auto-approve`, though this should be done cautiously and typically only in CI/CD pipelines with appropriate safeguards.

After apply completes, Terraform has created the resources in AWS and recorded their details in a state file named `terraform.tfstate` in your project directory. You can verify the bucket exists by checking the AWS console or running:

```
aws s3 ls | grep my-unique-bucket-name
```

Now let us modify the configuration to see how Terraform handles updates. Add versioning to the S3 bucket by editing `main.tf`:

```
resource "aws_s3_bucket" "example" {
  bucket = "my-unique-bucket-name-${random_id.suffix.hex}"

  tags = {
    Name        = "example-bucket"
    Environment = "development"
  }
}

resource "aws_s3_bucket_versioning" "example" {
  bucket = aws_s3_bucket.example.id

  versioning_configuration {
    status = "Enabled"
  }
}
```

Run `terraform plan` again:

```
Terraform will perform the following actions:

  # aws_s3_bucket_versioning.example will be created
  + resource "aws_s3_bucket_versioning" "example" { ... }

Plan: 1 to add, 0 to change, 0 to destroy.
```

Terraform detected that we added a new resource and plans to create it without modifying existing resources. After applying, versioning is enabled on the bucket.

If you modify an existing attribute instead, for example, changing the Environment tag from "development" to "staging", Terraform detects the change and plans an in-place update:

```
Terraform will perform the following actions:

  # aws_s3_bucket.example will be updated in-place
  ~ resource "aws_s3_bucket" "example" {
      ~ tags = {
          ~ "Environment" = "development" -> "staging"
            # (1 unchanged element hidden)
        }
      ~ tags_all = {
          ~ "Environment" = "development" -> "staging"
            # (1 unchanged element hidden)
        }
    }

Plan: 0 to add, 1 to change, 0 to destroy.
```

The ~ symbol indicates an in-place update. Terraform determines whether a change requires in-place update or resource replacement based on the provider's schema for each attribute. Some attributes can be modified after creation; others are immutable and require destroying and recreating the resource.

To remove all resources managed by this configuration, run `terraform destroy`:

```
$ terraform destroy

Terraform used the selected providers to generate the following execution plan.
Resource actions are indicated with the following symbols:
  - destroy

Terraform will perform the following actions:

  # aws_s3_bucket.example will be destroyed
  - resource "aws_s3_bucket" "example" { ... }

  # aws_s3_bucket_versioning.example will be destroyed
  - resource "aws_s3_bucket_versioning" "example" { ... }

  # random_id.suffix will be destroyed
  - resource "random_id" "suffix" { ... }

Plan: 0 to add, 0 to change, 3 to destroy.

Do you really want to destroy all resources?
  Terraform will destroy all your managed infrastructure.
  There is no undo. Only 'yes' will be accepted to confirm.

  Enter a value: yes

...

Destroy complete! Resources: 3 destroyed.
```

The destroy command asks for confirmation with extra emphasis because it removes everything. After destruction, the state file becomes empty (no managed resources), and running `terraform plan` shows nothing to do.

Reading Terraform Output

As configurations grow beyond a few resources, you need a way to extract useful information from what Terraform has created, resource IDs, connection strings, endpoint URLs, security group IDs that other systems might need. Terraform provides two mechanisms for this: the `terraform output` command and output blocks in your configuration.

You can query any attribute of any managed resource directly:

```
$ terraform output -raw aws_s3_bucket.example.bucket
my-unique-bucket-name-a3f7b2c1

$ terraform output -json aws_s3_bucket.example
{"bucket":"my-unique-bucket-name-a3f7b2c1","id":
↪  "my-unique-bucket-name-a3f7b2c1",...}
```

However, for values you want to expose as a stable interface from your configuration, especially when sharing state between different Terraform projects or integrating with external systems, define explicit output blocks. Add this to `main.tf`:

```
output "bucket_name" {
  description = "The name of the S3 bucket"
  value       = aws_s3_bucket.example.bucket
}

output "bucket_arn" {
  description = "The ARN of the S3 bucket"
  value       = aws_s3_bucket.example.arn
}
```

After applying, you can read these outputs:

```
$ terraform output
bucket_name = "my-unique-bucket-name-a3f7b2c1"
bucket_arn  = "arn:aws:s3:::my-unique-bucket-name-a3f7b2c1"

$ terraform output bucket_name
my-unique-bucket-name-a3f7b2c1
```

Outputs are particularly important when using modules, where they define the interface between a module and its caller. They also enable one Terraform configuration to reference resources created by another through remote state data sources, a pattern we will explore later when discussing multi-project architectures.

At this point you have completed the fundamental Terraform workflow: write configuration, initialize the project, plan changes, apply them, inspect outputs, and destroy when done. The remaining chapters build on this foundation, introducing the language features, architectural patterns, and operational practices needed for real-world use.

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